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## Title: MULTI-COMPONENT COEXTRUSION

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## TECHNICAL FIELD

This invention relates to methods and apparatus for forming a multiple component, composite polymer/wood fiber extrusion and a method for making the same. More specifically, the invention relates to a composite extrusion of the type described above having a multiplicity of components, including a high density, substantially hollow extrusion profile having inner and/or outer components having a different density coextruded with the high density component.

## BACKGROUND OF THE INVENTION

Milled wood products have formed the foundation for the fenestration, decking and remodeling industries for many years. Historically, ponderosa pine, fir, red wood, cedar and other coniferous varieties of soft woods have been employed with respect to the manufacture of residential window frames, residential siding and outer decking. Wood products of this type inherently possess the advantageous characteristics of high flexural modulus, good screw retention, easy workability (e.g., milling, cutting, paintability), and for many years, low cost. Conversely, wood products of this type have also suffered from poor weatherability in harsh climates, potential insect infestation such as termites, and high thermal conductivity. In addition to these inherent disadvantages, virgin wood resources have become scarce, thus the raw material cost for milled wood products has become correspondingly expensive.

In response to the above described disadvantages of milled wood products, the fenestration industry, in particular, adopted polyvinyl chloride as a raw material.

0 for the manufacture of hollow, lineal extrusions for  
subsequent assembly into window frames. Window frames  
manufactured from such lineal extrusions became an  
enormous commercial success, particularly at the lower end  
of the price spectrum. Window frames manufactured from  
5 hollow, lineal polyvinyl chloride (PVC) extrusions  
exhibited superior thermal conductivity, water absorption  
resistance (and thus rot resistance), insect resistance,  
and ultraviolet radiation resistance compared to painted  
ponderosa pine. Although such extrusions further enjoyed  
10 a significant cost advantage over comparable milled wood  
products, these polymer based products had a significantly  
lower flexural modulus (i.e., bending moment), were  
difficult if not impossible to paint effectively, and had  
a significantly higher coefficient of thermal expansion.  
15 By the mid 1990s, a number of window and door frame  
manufacturers attempted to combine the most desirable  
characteristics of extruded thermoplastic polymers and  
solid wood frame members by alloying PVC with wood fiber  
in an extruded product.  
20 U.S. Patent No. 5,486,553 to Deaner et al. discloses  
an extruded polymer/wood fiber thermoplastic composite  
structural member, suitable for use as a replacement for  
a wood structural member, such as for window frame  
components. The preferred thermoplastic component is  
25 polyvinyl chloride (PVC), and the preferred wood fiber  
component is sawdust. In a preferred embodiment of the  
invention, a double hung window unit is disclosed having  
cell, jamb and header portions comprising hollow, multi-  
compartment lineal extrusions which can be made from the  
30 disclosed thermoplastic polymer/wood fiber composite. The  
resulting extrusion has mechanical properties which are  
similar to wood, but have superior dimensional stability,  
and resistance to rot and insect damage as compared to  
conventional wood products.  
35 Problems relating to co-extrusion of wood fibers and  
a thermoplastic polymer component are well explained in

0 United States Patent No. 5,851,469 to Muller et al. issued  
December 22, 1998, the disclosure of which is incorporated  
herein by reference. Muller et al. described the typical  
prior art steps for co-extruding a thermoplastic polymer  
with wood fiber. In a first step, the wood fiber is dried  
5 using conventional techniques to a moisture content of  
less than 8% by weight. In a second step the wood fiber  
and plastic material are preheated to a temperature of  
approximately 176° F. to 320° F. In a third step, the  
materials are mixed or kneaded at a temperature of 248° F.  
10 to 482° F. to form a paste. In a fourth and final step,  
the paste is either injection molded or extruded into a  
final form. If the paste is extruded, the extrudate must  
be calibrated and cooled. The Muller et al. reference  
specifically addresses the problem of controlling the  
15 temperature of the extrudate through various stages of the  
extrusion process to prevent undesirable sheer stresses  
from arising during the extrusion process. Muller et al.  
also teach that a particular problem involved with wood  
fiber/thermoplastic composite extrudates involves  
20 volatiles in the wood component boiling off at extrusion  
temperatures causing an undesirable foaming of the  
extrudate.

In addition, extruded polymer/ wood thermoplastic  
composite structural members allowed manufacturers to  
25 limit the amount of expensive thermoplastic materials used  
in the extrusion by increasing the percentage of low cost  
waste wood product incorporated into the process.  
Substantial advancements have been made in this art  
whereas as of the filing date of this application,  
30 concentrations of wood fiber in a hollow core,  
thermoplastic extrusion up to 30 to 40 percent are known.  
Unfortunately, adding significant quantities of wood fiber  
to the thermoplastic polymer/wood fiber composite degrades  
the flexural modulus (i.e., bending moment) of the  
35 extrusion. Thus, manufacturers often resort to the use of  
U-shaped metal channels which reside inside hollow

0 sections of the longitudinal extrusion to provide  
increased stiffness, as well as angled metal members  
incorporated into interior components of such structures  
and corners thereof. The use of such additional  
5 structural members disadvantageously increases the cost of  
assembling products of this type, as well as decreases the  
thermal efficiency of these products.

Some manufacturers have moved in a different  
direction by preparing foamed lineal extrusions, with and  
without a wood fiber content. Such extrusions address the  
10 difficulties in connecting thin wall, hollow extrusions at  
corners (typically done by thermal welding) by providing  
a large surface area for joining. In addition, screw  
retention and thermal efficiency may be substantially  
improved in foamed extrusions of this type. Further yet,  
15 foamed extrusions containing a high wood fiber content are  
readily paintable and can be provided with a surface  
texture which mimics solid wood. The assignee of the  
present invention has developed improved techniques for  
increasing the wood fiber content of such foamed  
20 extrusions as disclosed in United States Patent  
Application Serial No. 09/452,906, entitled "Wood Fiber  
Polymer Composite Extrusion and Method", filed December 1,  
1999, the disclosure of which is incorporated herein by  
reference. Unfortunately, while such foamed lineal  
25 extrusions advantageously exhibit improved heat  
deflection, Vicat softening point, screw retention, and  
lower density (i.e., decreased raw material cost) as  
opposed to rigid, hollow core PVC extrusions, foamed  
extrudates typically have a lower flexural modulus than  
30 comparable rigid, thin walled, hollow core PVC extrusions.

In an attempt to combine the specific structural  
advantages of different types of polymers, at least one  
manufacturer in the fenestration industry has attempted to  
produce a multi-component extrusion having an extruded  
35 foamed material as one component, flexible flanges as  
another component, and a partial capstock as a third

0 component. An example of an extrusion of this type is disclosed in United States Patent No. 5,538,777 to Pauley et al. entitled "Triple Extruded Frame Profiles", issued July 23, 1996. That patent discloses a three- component extrusion for a window sash. The main component of the 5 extrusion in cross-section is a polyvinyl chloride foam core, optionally including a fiber component. The core has a recess forming a U-shaped channel for receipt of glass panes. The panes are held in place by flexible flanges extending normal to the inside of the channel in 10 the form of a flexible material which is used to form the flexible flanges and/or seals. Dupont Alcryn™ is disclosed as an appropriate material for the flanges. The extrusion is also disclosed as having a partial capstock, 15 preferably acrylic styrene acrylonitrile (ASA) which is provided only on the portion of the exterior of the extrusion which will be exposed to weathering. Although this extrusion enjoys the low cost advantages of a foamed, thermoplastic/wood fiber core and the weatherability of a partial capstock, it is believed that an extrusion of this 20 type has insufficient flexural modulus for use in anything other than as a sash portion of a window assembly. That is, it is believed that metallic channel stiffeners, and the like, would still be necessary if this type of extrusion construction was employed as a main frame 25 element.

Thus, a need exists for a lineal extrusion for use in the fenestration, decking and remodeling industries which combines a low raw material cost with high tensile, compressive, bending moment, and impact strength; improved 30 weldability with respect to hollow core extrusions; high wood fiber content (reduced cost); and high workability (e.g., millable, paintable, and good screw retention). In addition, there is a need for an extrusion of the type described above which is highly durable, being resistant 35 to rot, mildew, and ultraviolet degradation.

## 0 SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a continuous, lineal multi-component polymer composite extrusion having low raw material cost; high tensile, compressive, bending moment, and impact strength; 5 improved weldability with respect to hollow core extrusions; high wood fiber content; and high workability.

It is a further object of the present invention to achieve the above object by a method and apparatus which provides a continuous, lineal multi-component polymer 10 composite extrusion which is highly durable, being resistant to rot, mildew, and ultraviolet degradation.

It is yet a further object of the invention to achieve the above objects with a manufacturing process capable of varying the ultimate macroscopic properties of 15 the resulting extrudate so as to closely match the differing physical requirements of the fenestration, decking and siding markets.

The invention achieves the above objects and advantages, and other objects and advantages which will 20 become apparent from the description which follows, by providing a multi-component, longitudinally continuous extrusion having a first, high density, thin wall composite member having a thermoplastic component and a cellulosic fiber component. The inventive extrusion 25 further has a second, low density foamed member, consisting of a foamed, thermoplastic polymer coextruded with the first member in a plastic state, substantially contemporaneously with the first member, in an extrusion die so as to be laterally coextensive with, and 30 molecularly bonded to, either an inside hollow portion of the first, thin wall high density member, an outside of the first, thin wall, high density member, or both.

In the preferred embodiment, the inventive extrusion 35 may be capped with a thin layer of acrylic styrene acrylonitrile (ASA) or polyvinyl chloride (PVC).

0        In alternate embodiments of the invention, the low  
density foamed member may include a substantial wood fiber  
content, particularly when the second, low density foamed  
member is on the outside of the first, thin wall, high  
density composite member and a thermoplastic cap is not  
5        employed. The thermoplastic cap may be provided with a  
highly weatherable, thermoplastic polymer on one side of  
the extrusion (to be exposed to the outdoor portion of a  
building) and a highly paintable thermoplastic polymer on  
an opposite side of the extrusion, to be exposed to an  
10      indoor portion of the building.

15      The invention includes apparatus in the form of a  
multi-plate extrusion die for manufacturing the above  
extrusions, including an introductory plate for passage  
therethrough of a primary extrudate from a principal  
extruder, a mandrel plate downstream of the introductory  
plate for receipt of the primary extrudate which will  
become the first, thin wall, high density composite  
member. The mandrel plate has suspended within an  
aperture therein a first elongated mandrel wherein the  
20      first mandrel is substantially hollow and has therein a  
second mandrel substantially suspended therein in a spaced  
apart relationship from the side walls of the first  
elongated mandrel so as to form an elongated, hollow  
interstitial void between the first and second mandrels.  
25      The interstitial void is thus available for introduction  
of the second, low density foamed material which can  
become laterally coextensive with, and molecularly bonded  
to, one of the inner side walls of the first member.  
Finally, a secondary plate is positioned between the  
30      introductory and mandrel plates so that in one alternate,  
preferred embodiment of the invention the second, low  
density foamed extrudate can be provided on the outer side  
wall of the first, thin wall, high density composite  
member so that foamed material can be provided on both the  
35      inside and the outside of the thin wall extrusion, as well  
as on the inside or the outside of the hollow core

0 extrusion exclusively. A capstock plate can be provided downstream of the mandrel plate for adding a third extrudate in the form of a capstock to the final extrudate. Elongated, tapered fins are preferably provided to support the first elongated mandrel with respect to the aperture in the mandrel and also to support the second mandrel in a spaced apart relationship with respect to inner side walls of the first hollow mandrel.

5 The invention includes a method of making the above described multi-component, longitudinally continuous extrusion with the above described introductory, mandrel, and secondary die plates which includes the steps of preparing a thermoplastic primary extrudate and a secondary thermoplastic extrudate, introducing the primary extrudate in a plastic state into the introductory plate, 10 positioning a mandrel plate downstream of the introductory plate, and introducing the secondary extrudate in a plastic state into a void between the first and second, coaxially spaced mandrels in the mandrel plate, so that an elongated final extrudate having at least two different 15 longitudinally continuous, molecularly bonded 20 thermoplastic components exit the mandrel plate.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is an environmental view of a first 25 embodiment of a multi-component, polymer composite extrusion of the present invention.

Figure 2 is a an exploded schematic representation of a plurality of extrusion die plates employed in the manufacture of the extrusion shown in Figure 1.

30 Figure 3 is a left hand, environmental view of a mandrel plate die of the die shown in Figure 2.

Figure 4a is a right hand perspective view of the mandrel plate die shown in Figure 3.

35 Figure 4b is a left hand perspective view of a floating mandrel of the mandrel die shown in Figure 4a.

0 Figure 4c is a right hand perspective view of the floating mandrel shown in the mandrel die of Figure 4a.

5 Figure 5 is a schematic representation of a polymer flow in a plastic state in the die assembly shown in Figure 2.

10 Figure 6 is an environmental view of a second embodiment of a multi-component, polymer composite extrusion of the present invention.

15 Figure 7a is a right hand, perspective view of a mandrel plate having a dual floating mandrel therein for manufacture of the extrudate shown in Figure 6 in conjunction with some of the die plates shown in the die plate assembly of Figure 2.

20 Figure 7b is a left hand environmental view of a mandrel plate having a dual floating mandrel therein for manufacture of the extrudate shown in Figure 6 in conjunction with some of the die plates shown in the die plate assembly of Figure 2.

25 Figure 8a is an enlarged, right hand perspective view of the dual floating mandrel shown in Figure 7a.

30 Figure 8b is a left hand perspective view of the dual floating mandrel shown in corresponding Figure 7b.

35 Figure 9 is a schematic representation of a third alternate embodiment of the invention.

25 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

40 A first preferred embodiment of a multi-component, composite polymer/wood fiber continuous lineal extrusion of the present invention is generally indicated at reference numeral 10 of Figure 1. The extrusion includes a first, high density, thin wall component 12, having an inner side wall 14 defining at least one hollow section in profile. The multi-component extrusion 10 further has a second, low density foamed thermoplastic member 16 which is coextruded with, and substantially fills, the hollow section defined by inner side wall 14. As will be

0 described in further detail hereinbelow, the second  
component 16 is preferably formed of a foamed  
thermoplastic member which is molecularly bonded to, and  
substantially laterally coextensive with, the inner  
sidewall 14. In this preferred embodiment, the first  
5 component 12 has an outer side wall 18 defining the  
exterior surface of the first component. In this first  
preferred embodiment, the outer side wall 18 supports a  
thermoplastic cap 20 which is substantially coextruded  
with the first and second components 12, 14, so as to be  
10 molecularly bonded to the outer side wall 18. The  
thermoplastic cap is preferably formed from a highly  
weatherable, thermoplastic polymer such as polyvinyl  
chloride (PVC).

The multi-component, composite polymer/wood fiber  
15 extrusion 10 shown in Figure 1 is suitable for use as  
vertical and horizontal members of a window sash. The  
extrusion defines a substantially U-shaped channel,  
generally indicated at reference numeral 22, for the  
receipt of weatherstripping material, and the like (not  
20 shown). The extrusion 10 shown in Figure 1 also has on  
the upper portion thereof a substantially L-shaped surface  
24, having a lower ledge 26 and at right angles thereto a  
vertical edge 28. When assembled into a window sash, the  
extrusion 10 is cut into four desired lengths, having each  
25 end of each section mitered at an appropriate angle. The  
mitered edges are then thermally welded in a manner well  
known to those of ordinary skill in the art so as to form  
a complete sash frame. Extrusion 10 of the present  
invention advantageously presents a cross-section at each  
30 miter joint having a substantially continuous surface of  
thermoplastic material. Thus, the entire cross-sectional  
surface area available for thermal welding is  
substantially greater than that of a continuous lineal  
extrusion being substantially hollow in profile. In  
35 addition, it is relatively easy to align adjacent members

0 of the sash because of the large surface area available  
for welding.

In the context of a complete sash structure, the  
lower edge 26 of the extrusion 10 is well adapted to  
receive edges of glass panes (not shown) in a moveable or  
5 fixed sash. Vertical edge 28 provides a support surface  
for a rearward pane member of, for example, a double-pane  
sash. The extrusion 10 is also provided on a forward edge  
thereof with a bead pocket, generally indicated at  
10 reference numeral 30, for receipt of a bead (not shown)  
for retaining an outer pane of a double pane window sash.  
Thus, the completed sash defines an exterior surface 32  
15 for the sash and an interior surface 34. In this  
embodiment, the exterior surface 32 is exposed to  
weathering, while the interior surface 34 [extending from  
the vertical edge 28 around the rear (hidden in Figure 1)  
20 surface of the thermoplastic cap 20] is exposed to the  
interior of a home or the like. The thermoplastic cap 20  
may therefore be preferably provided with the interior  
surface 34 being extruded from a thermoplastic polymer  
25 that is highly paintable, whereas the exterior surface 32  
is extruded with a thermoplastic polymer that is highly  
weatherable.

Figure 2 illustrates a die assembly 40 consisting of  
a series of individual die plates, 44, 46, 48, 50, 52, 54,  
25 56, and 58, for manufacturing the multi-component  
extrusion 10 shown in Figure 1. The manner of use of such  
dies is well known to those of ordinary skill in the  
thermoplastic extrusion art and is well described in  
United States Patent Application Serial No. 09/452,906,  
30 entitled "Wood Fiber Polymer Composite Extrusion and  
Method" assigned to the assignee of the present invention.  
Disclosure of that application is incorporated herein by  
reference. Nevertheless, it is sufficient to state that  
the die assembly 40 shown in Figure 2 is intended for use  
35 with a plurality of conventional extruders, such as  
conventional twin screw extruders, each of which includes

0 a hopper or mixer for accepting a feed stock consisting of  
a thermoplastic polymer and/or wood composite pelletized  
material, a conduit for connecting the hopper with a  
preheater for controlling the temperature of an admixture  
of the feed stock in the hopper, and optionally an inlet  
5 for introducing foaming agents in the case of a foamed  
component. The preheater is fluidly connected to a multi-  
screw chamber for admixing feedstock with the foaming  
agent (if present) and other conditioners to be described  
hereinbelow under controlled conditions of temperature and  
10 pressure. The multi-screw chamber of each extruder is  
connected to an appropriate one of the die assembly plates  
shown in Figure 2 for producing the multi-component  
extrusion 10 shown in Figure 1. The extrudate is then  
preferably calibrated in a conventional calibrator to  
15 result in a final product shown in Figure 1. Appropriate  
extruding machines are available from Cincinnati Millacron  
Corporation, Batavia, Ohio, USA.

As best seen in Figure 2, one of the hereinabove  
described extruders (not shown) is fluidly connected to an  
20 introductory plate 44 for introduction of a primary  
extrudate which will become the hollow high density  
component 12 shown in Figure 1. The primary extrudate is  
introduced through a primary aperture 60 in the  
introductory plate 44. A first shaping plate 46 has a  
25 plurality of internal conduits 47 for directing the flow  
of the primary extrudate to corresponding conduits in a  
secondary extrudate die plate 48. Secondary extrudate die  
plate 48 has an inlet 49 for introduction of a secondary  
30 extrudate which will become the second, low density foamed  
thermoplastic component 16 of the extrusion shown in  
Figure 1. The inlet 49 is fluidly connected to a  
secondary shaping die plate 50 by way of an internal  
secondary conduit 51. Both the internal primary and  
35 secondary conduits 47, 51 are in fluid communication with  
a mandrel plate 52 which supports a first mandrel 53(a) by  
means of a plurality of longitudinally elongated fins

0 53(b) within the internal primary conduit 47. An external surface 53(c) of the first mandrel 53(a) is the inner forming surface for the primary extrudate. As best seen in Figures 3 & 4(a)- 4(c), the first mandrel 53(a) is substantially hollow and has suspended therein a second  
5 mandrel 53(d). The second mandrel 53(d) is suspended within the hollow interior of the first mandrel 53(a) by elongated, longitudinally tapering fins 53(e). Thus, the first and second mandrels 53(a) and 53(d) form a two-stage floating mandrel within the internal primary conduit 47.  
10 The secondary extrudate which will ultimately comprise the second, low density foamed thermoplastic component 16 of the multi-component extrusion 10 of Figure 1 enters the die assembly 40 of Figure 2 through the secondary extrudate inlet 49, the internal secondary conduit 51, and  
15 then the voids formed between the first and second mandrels. A mandrel shaping plate 54 is positioned adjacent to the mandrel plate 52 and is in fluid communication therewith for further shaping the principal extrudate about the external surface 53(c) of the first  
20 mandrel 53(a). The tapering fins 53(e) taper in thickness from the maximum thickness shown in Figure 4b to a thin edge (hidden from view) approximately one-quarter of the length of the first and second mandrels in a manner well known to those of ordinary skill in the art so that at the  
25 exit end of the first and second mandrels the fins end and are absent from the void 55. The die assembly 40 further includes first and second capstocking dies 56, 58, having corresponding first and second internal channels 57, 59 for introduction of a third extrudate in the form of a  
30 capstock from a third extruder (not shown) through capstocking inlet 62 in first capstock die 56, as best seen in Figure 5.

Figure 5 is a schematic representation of extrudate flow through die assembly 40, illustrating flow of the primary extrudate 64, the secondary extrudate 66, and the third extrudate 68. As stated above, the primary

0 extrudate forms the thin wall, high density, hollow component 12; the secondary extrudate forms the second, low density foamed thermoplastic component 16; and the third extrudate forms the thermoplastic cap 20 of the extrusion 10 shown in Figure 1.

5 Table 1 hereinbelow illustrates one preferred formulation used for the principal extrudate used in the production of the thin wall, high density hollow component 12, shown in Figure 1. In this preferred embodiment, the thin wall, high density hollow component 12 consists of a  
10 polyvinyl chloride (PVC)/wood flour composite. The inclusion of wood flour is preferred, but nevertheless is optional.

15

TABLE 1  
PVC/Wood Flour Composite

| INGREDIENT                         | PERCENT | SUPPLIER                        | CITY       | STATE            |
|------------------------------------|---------|---------------------------------|------------|------------------|
| PVC resin                          | 50.25   | Shintech                        | Freeport   | Texas            |
| 20 Stabilizer                      | 0.75    | Witco                           | Taft       | Louisiana        |
| Plasticizer                        | 1.51    | Kalama                          | Kalama     | Washington       |
| Process Aid<br>TR-060              | 1.96    | Struktol                        | Stow       | Ohio             |
| 25 Lubricant<br>PCS-351E           | 0.50    |                                 | Cincinnati | Ohio             |
| Modifier<br>B-360                  | 5.03    | Morton                          | Morgantown | West<br>Virginia |
| 30 Wood Flour<br>(60 Mesh<br>Pine) | 40.00   | GE<br>American<br>Wood<br>Fiber | Schofield  | Wisconsin        |

The secondary extrudate 66 which forms the second, low density foamed thermoplastic component 16 in the preferred embodiment shown in Figure 1 consists of a  
35 polyvinyl chloride (PVC) foamed core. Table II

15

0 illustrates one preferred formulation of the secondary extrudate 66.

TABLE II  
PVC Foam Core

5

|    | INGREDIENT                     | PERCENT | SUPPLIER            | CITY            | STATE             |
|----|--------------------------------|---------|---------------------|-----------------|-------------------|
|    | PVC resin<br>SE 650            | 77.97   | Shintech            | Freeport        | Texas             |
| 10 | Stabilizer<br>MK 1915          | 1.25    | Witco               | Taft            | Louisiana         |
|    | Lubricant<br>VGE-1875          | 1.55    | Cognis              | Kanakee         | Illinois          |
| 15 | Calcium<br>Stearate            | 0.39    | Synpro              | Cleveland       | Ohio              |
|    | Lubricant<br>AC-629A           | 0.12    | Cognis              | Kanakee         | Illinois          |
|    | Modifier<br>PA-40              | 4.68    | Kaneka              | Pasadena        | Texas             |
| 20 | Titanium<br>Dioxide            | 0.78    | Huntsman<br>Tioxide | Lake<br>Charles | Louisiana         |
|    | Filler UFT                     | 2.34    | OMYA                | Florence        | Vermont           |
|    | Foaming<br>Agent<br>Hydrocerol | 9.36    | Clariant            | Charlotte       | North<br>Carolina |
| 25 | Process Aid<br>TR-060          | 1.56    | Struktol            | Stow            | Ohio              |

30 A preferred formulation used for the third extrudate 68, forming the thermoplastic cap 20 in the multi-component extrusion 10 of Figure 1, is illustrated in Table III, wherein the thermoplastic has favorable weatherability characteristics.

16

0

TABLE III  
PVC Cap

| INGREDIENT            | PERCENT | SUPPLIER            | CITY              | STATE     |
|-----------------------|---------|---------------------|-------------------|-----------|
| PVC Resin<br>SE-650   | 76.161  | Shintech            | Freeport          | Texas     |
| Stabilizer            | 0.610   | Witco               | Taft              | Louisiana |
| 401P                  | 0.228   | PQ Corp.            | Kansas City       | Kansas    |
| Lubricant<br>VGE-3041 | 2.44    | Cognis              | Kanakee           | Illinois  |
| Anti-stat             | 0.38    | Clariant            |                   | Germany   |
| Modifier K-<br>37     | 4.95    | Kaneka              | Pasadena          | Texas     |
| Calcium<br>Carbonate  | 3.04    | OMYA                | Florence          | Vermont   |
| TiO <sub>2</sub>      | 7.62    | Huntsman<br>Tioxide | Lake<br>Charles   | Louisiana |
| Calcined<br>Clay      | 4.57    | Burgess             | Sanders-<br>ville | Georgia   |

Alternatively, thermoplastic component 20 may be provided by an alternate formulation of the third extrudate 68 in the form of a highly paintable thermoplastic cap 20. A preferred extrudate formulation is illustrated in Table IV, wherein the principal ingredients of that extrudate are Styrene Acrylonitrile (SAN) and Acrylic Styrene Acrylonitrile (ASA).

25

TABLE IV  
ASA Cap

| INGREDIENT | PERCENT | SUPPLIER | CITY       | STATE            |
|------------|---------|----------|------------|------------------|
| SAN B-578  | 69.125  | GE       | Morgantown | West<br>Virginia |
| ASA B-984  | 29.625  | GE       | Morgantown | West<br>Virginia |

| INGREDIENT       | PERCENT | SUPPLIER | CITY       | STATE         |
|------------------|---------|----------|------------|---------------|
| EBS Advawax 280  | 0.50    | Morton   | Cincinnati | Ohio          |
| Calcium Stearate | 0.50    | Synpro   | Cleveland  | Ohio          |
| UV Absorber      | 0.25    | GE       | Morgantown | West Virginia |

5 An alternate embodiment of the multi-composite polymer/wood fiber extrusion 10' is shown in Figure 6. This alternate embodiment employs a first thin wall, high density, hollow component 12, substantially identical to the corresponding component of Figure 1. In addition, a second, low density foamed thermoplastic component 16 is employed which is also identical to that shown in Figure 1, with a corresponding reference numeral. However, the extrusion 10' of Figure 6 has a first component 12, having a slightly different shape in profile, including an intermediate web portion 80, dividing the interior cavity 14 shown in Figure 1 into twin cavities in which the second, low density foamed thermoplastic component 16 resides. The alternate embodiment 10' also includes a thermoplastic cap 20 identical to that shown with respect to the first embodiment 10 shown in Figure 1. However, the alternate embodiment 10' is provided with a further, low density foamed thermoplastic component 82, intermediate the thermoplastic cap 20 and the exterior surface 18 of the thin wall, high density component 12. The further, low density foamed component 82 may be formed from an extrudate having a composition identical to the second, low density foamed thermoplastic component 16, as shown in Table II hereinabove.

30 The alternate embodiment 10' of the multi-component extrusion shown in Figure 6 is manufactured utilizing a modified form of the die assembly 40 shown in Figure 2. In this alternate embodiment, the mandrel plate 52 is replaced with an alternate mandrel plate design 52', shown

0 in Figures 7a and 7b. In this alternate embodiment, the  
 5 first mandrel 53(a)' is provided with a first section 84  
 and a second section 86, interconnected by a fin 88. Each  
 of the sections includes an outer, hollow mandrel 90 and  
 an inner, floating mandrel 92, having a solid cross-  
 10 section. Each of the mandrels is supported by a plurality  
 of fins, shown with respect to the first embodiment. In  
 addition, the alternate embodiment of the mandrel plate  
 15 52' is provided with a tertiary extrudate inlet 94, which  
 is in fluid communication with an internal tertiary  
 conduit 96 for introduction of a tertiary extrudate which  
 will result in the further, low density foamed component  
 20 82, shown in Figure 6. The tertiary extrudate may have  
 the same formulation as shown in Table II with respect to  
 the secondary extrudate 66 and second, low density foamed  
 25 thermoplastic component 16 of the first embodiment 10.

Further alternate embodiments of the invention are  
 30 contemplated. By way of example and not limitation, the  
 capstock material 20 of alternate embodiment 10' may be  
 eliminated, and the tertiary extrudate which forms the  
 further, low density foamed component 82 may be replaced  
 20 with a formulation having a significant wood flour  
 component and improved paintability characteristics  
 resulting from the formulation illustrated in Table V,  
 below, in which the principal thermoplastic component is  
 25 Styrene Acrylonitrile (SAN) polymer resin.

TABLE V  
 SAN/Wood Flour Foamed Composite

| INGREDIENT | PERCENT<br>(by<br>weight) | SUPPLIER            | CITY      | STATE       |
|------------|---------------------------|---------------------|-----------|-------------|
| SAN Resin  | 70-90                     | Kumho               |           | South Korea |
| Wood Flour | 5-25                      | American Wood Fiber | Schofield | Wisconsin   |

| INGREDIENT                   | PERCENT<br>(by<br>weight) | SUPPLIER        | CITY       | STATE            |
|------------------------------|---------------------------|-----------------|------------|------------------|
| 0 ABS<br>Modifier            | 2-8                       | GE              | Morgantown | West<br>Virginia |
| 5 Lubricant                  | 0.1-0.5                   | Synpro          | Cleveland  | Ohio             |
| Foaming<br>Agent<br>80-428-1 | 0.5-3.0                   | Color<br>Matrix | Cleveland  | Ohio             |

10 In each of the above-described embodiments, all of the components exit the second capstocking die plate 58 in a molten (i.e. plastic) state and are introduced into a calibration unit (not shown) where the extrudate is cooled to shape. The resulting multi-component extrusion is preferably cooled further in a conventional cooling tank. Subsequent thereto the resulting extrudate enters a puller 15 before it is cut to length by a saw subsequent to assembly into a window frame or the like.

15 The above described methods and apparatus are also applicable for the production of decking and siding. By way of example, a third, alternate embodiment of the invention is generally indicated at reference numeral 10' in Figure 9. This embodiment employs a component structure substantially identical with respect to the second embodiment 10 shown in Figure 6 where like reference numerals refer to like structure. As will be appreciated by those of ordinary skill in the art, 20 appropriate materials can be selected from those shown in Tables I through V above to achieve the desired macroscopic mechanical properties and weather resistance of the resulting multi-component extrusion 10'. Similarly, a decking material can be provided in the form 25 shown with respect to the first preferred embodiment 10, shown in Figure 1. In this alternate embodiment the cross-sectional shape of the extrusion is substantially identical to decking in the form of standard dimensional 30

20

0 lumber wherein the multi-component composite decking extrusion has a foam composite core shown at reference numeral 16 in Figure 1, surrounded by a composite shell core corresponding to reference numeral 12 of Figure 1, and a cap corresponding to reference numeral 20 in Figure  
5 1.

In view of the above, the invention is not to be limited by the above disclosure but is to be determined in scope by the claims which follow.